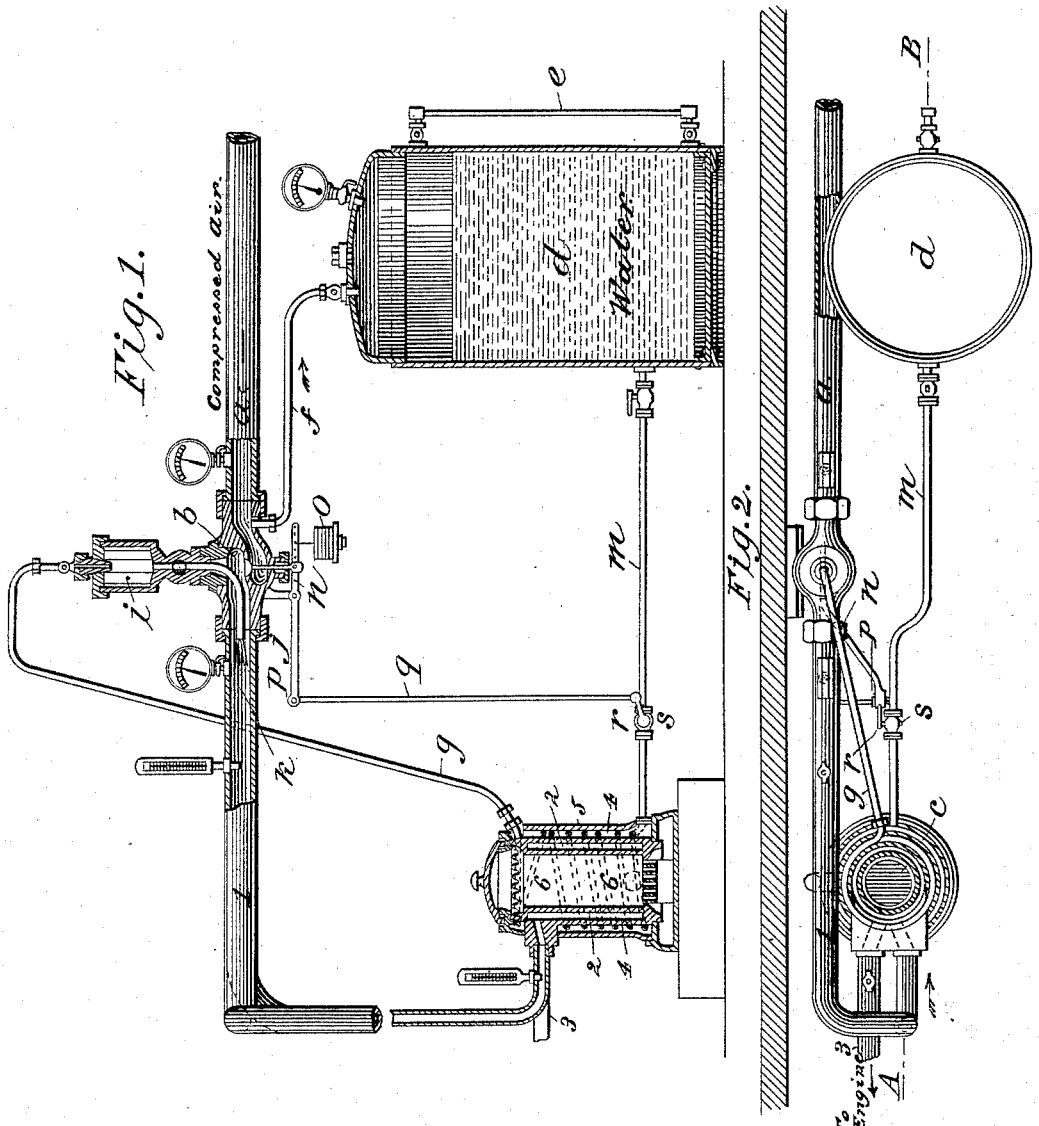
(No Model.)

V. POPP.

MEANS FOR UTILIZING COMPRESSED AIR FOR THE PRODUCTION OF MECHANICAL POWER.

No. 456,594. Patented July 28, 1891.



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UNITED STATES PATENT OFFICE.

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MEANS FOR UTILIZING COMPRESSED AIR FOR THE PRODUCTION OF MECHANICAL POWER.

SPECIFICATION forming part of Letters Patent No. 456,594, dated July 28, 1891.

Application filed April 9, 1889. Serial No. 306,619. (No model.) Patented in France November 8, 1888, No. 193,980; in Belgium November 14, 1888, No. 83,946, and in England November 22, 1888, No. 17,006.

To all whom it may concern:

Be it known that I, VICTOR POPP, of the city of Paris, France, have invented Improvements in the Method or Means of Utilizing Compressed Air for the Production of Mechanical Power, (for which I have obtained Letters Patent in France for fifteen years, dated November 8, 1888, No. 193,980; in Belgium for fifteen years, dated November 14, 1888, No. 83,946, and in England for fourteen years, dated November 22, 1888, No. 17,006,) of which the following is a full, clear, and exact description.

It is well known that when compressed air is used for the production of motive power—as, for instance, in the system associated with my name and patented June 25, 1889, No. 405,971—it is very advantageous for the air to be superheated with the object of obtaining a greater useful effect.

The present invention has for its object to further increase this effect, the method involved in this invention being claimed in my application, Serial No. 349,380, filed April 24, 1890, and the apparatus for carrying the method into effect being claimed herein.

According to my invention distilled water or other suitable liquid, previously heated, is injected into the pipe or conduit which supplies the highly-heated compressed air to the motor. This injection is effected under pressure at or before the moment of consumption of the compressed air in the form of atomized liquid or spray. The compressed air is by this means saturated with moisture, which is transformed into superheated steam by the heat contained in the air. A higher pressure is thereby obtained, which allows of a more favorable rate of expansion in the motor. The moisture present in the air also serves as a valuable lubricant for the parts of the motor.

One arrangement which I may employ for carrying this invention into practice is shown by way of example in the annexed sheet of illustrative drawings. The compressed air is supplied from a suitable source (not shown) by a pipe *a* under a constant pressure, which is maintained by means of an automatic pressure-regulator. (Not shown.) The compressed air passes through a valve *b*, which, since there is always maintained a constant pressure in the pipe *a*, allows only a constant but somewhat lower pressure to reach the motor, this valve opening or closing according as the motor requires more or less speed or power. The water or other liquid to be injected is contained in a reservoir *d*, provided with a gage-glass *e* or other suitable device for indicating the level of the liquid. The reservoir is hermetically closed, and its contents are subjected to the same constant pressure as that in the pipe *a* by means of a connecting-pipe *f*, which opens into the pipe *a* in front of the valve *b*.

The reservoir *d* is provided with a screw-plug, which can be replaced by a union forming the end of the delivery-pipe of a small pump, hereinafter referred to. This reservoir *d* is connected by a pipe *m* to a heater which serves to heat the compressed air. This heater receives the compressed air before its admission to the motor. The air passes by a pipe 1 into a series of passages formed by baffle-plates which compel the air to pass round the furnace while flowing alternately upward and downward in the heating device. The heated air passes out by a pipe 3, which conveys it to the motor. The heat radiated outward through the casing 4, surrounding the said baffle-plates, as well as the heat of the products of combustion, which go to the chimney, is utilized to heat the injection-water of the reservoir *d*. For this purpose between this casing 4 and the outer casing 5 of the heater is arranged a coil of piping *b*, dimensioned according to the most suitable temperature to be given to the injection-liquid. The water from the reservoir *d* is forced into the coil *b* by reason of the difference between the pressure existing in the pipe *a* in front of the valve *b*, which is a constant pressure, and the pressure in the pipe 1 behind that valve, which is a variable pressure, varying according to the working of the motor. The liquid is driven into the heating-coil 6 with a force proportionate to the difference in the pressures. The liquid, being thus heated in the coil, is forced by the action of this difference in the pressures out through a pipe *g* into a receiver *i*, provided with means for rendering visible the volume of discharge. From this

receiver the heated liquid passes into an atomizing or spraying-pipe or device *j*, which opens into the pipe 1, supplying the compressed air to the heater. The atomized liquid is sucked or drawn along at *k* by the current of compressed air, which is thereby saturated with moisture before entering the heater. By the action of the high temperature in the heater the liquid mixed with the air is changed into steam, which causes an increase of pressure of the motive fluid, while diminishing the consumption. The difference in pressure which forces the water into the coil is variable, since one of the pressures is itself variable, while the other is constant. The amount of water injected and drawn along by the compressed air will therefore also be variable. The proportionate discharge of this liquid is effected in an automatic manner; but it may also be effected mechanically by means of the following arrangement, which regulates the supply of liquid according to the requirements and proportionally to the consumption of compressed air by the motor. A lever *n*, connected to the valve *b*, carries the counter-weight *o*, and is extended to *p*. It is here jointed to a rod *g*, which is jointed to the end of a lever *r*, fixed on the plug of the cock *s*, inserted in the pipe *m*, forming the communication between the reservoir *d* and the heater. When the valve *b* rises in order to allow a greater quantity of compressed air to pass, the lever *r* is operated to open the plug of the cock *s*, so as to allow a greater quantity of water to pass into the coil. A pressure-gage may be placed on the pipe *a* in front of the valve *b* to indicate the constant pressure. A pressure-gage and a thermometer may be placed on the pipe 1 behind the valve *b* to indicate the pressure and the temperature of the compressed air mingled with atomized liquid. The reservoir *d* is also provided with a pressure-gage which should always agree with that on the pipe *a*.

A thermometer may be placed on the pipe 3, which supplies the compressed air mixed with steam to the motor, in order to indicate the temperature of the mixture.

In order that the water in the reservoir *d* may be renewed without interference with the working of the apparatus, the exhaust-pipe of the motor may be immersed in a sump or other reservoir of water. The steam mixed with the compressed air after its action on the motor becomes condensed in this reservoir, and a small pump, hereinbefore referred to, worked by hand or by the motor itself, returns to the reservoir *d* the water which has been injected. It is thus practically always the same liquid which is injected, with the addition of a quantity of fresh liquid to make up for loss by leakage and evaporation.

By the means hereinbefore described the useful effect of the motive force of the compressed air employed may be increased almost without extra cost.

In place of water, any other suitable liquid or substance may be employed for the purpose of injection which shall be capable of producing by admixture with the compressed air a fluid whose motive force will be added to that of the said compressed air.

I claim—

1. The combination, with pipe *a*, leading from a distant source of compressed-air transmission, of a local receiving apparatus for motive power, consisting of a reservoir of liquid maintained under pressure, a heater connected to said reservoir and receiving the liquid therefrom, and a connection from the said heater to the pipe *a*, by means of which the liquid after being heated is mingled with the compressed air in said pipe and is conducted therein to a motor operated by the combined pressure of the air and liquid vapor.

2. The combination, with pipe *a*, of a reservoir of liquid *d*, a connection therefrom to pipe *a*, by means of which the pressure in pipe *a* is transmitted to the liquid in the reservoir, a connection from the reservoir to the heater, and a connection from said heater conducting the liquid to pipe *a*, by which it is injected therein.

3. The combination, with pipe *a*, divided into two parts by valve *b*, of a reservoir of liquid connected to pipe *a* on one side of said valve, so as to have the same pressure, and a pipe leading from reservoir *d* through a heater and terminating in the pipe *a* on the opposite side of the valve *b*, whereby the liquid from the said reservoir is forced into pipe *a*.

4. The combination, with pipe *a*, connected to a compressed-air supply, of a reservoir of liquid maintained under pressure by means of a connection to the said pipe, a pipe *m*, leading from said reservoir to a heater, and a connection leading from said heater to pipe *a*, passing through the same heater and thence to a motor, by means of which arrangement the liquid is heated and injected into the compressed-air supply, and the combined expansive force of the mixture after an additional heating is utilized in a motor.

5. The combination, with pipe *a*, connected to a compressed-air supply, of a weighted valve *b*, regulating the passage of air in the pipe, a reservoir of liquid, a pipe leading therefrom to a heater, and a valve in said connecting-pipe attached to said valve *b*, so as to be operated correspondingly therewith.

6. The combination, with pipe *a*, of regulating-valve *b*, a heater to which the pipe *a* leads, a reservoir of liquid, a connection from pipe *a* upon one side of valve *b*, leading to said reservoir, a connection-pipe leading from the reservoir to the heater, and a connection-pipe from the heater terminating in pipe *a* at a point on the opposite side of valve *b*.

7. The combination, with pipe *a*, connected to a compressed-air supply, of a reservoir of liquid under pressure, and a connection from

said reservoir through a heater to pipe *a*, terminating in an atomizing device directed along the current of compressed air, by means of which the liquid is drawn along by the said current and mixed with the air.

The foregoing specification of my improvements in the method or means of utilizing compressed air for the production of mechanical power signed by me this 12th day of February, 1889.

VICTOR POPP.

Witnesses:
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